Ref:21-055	Received: 11 February 2021	Issued: 1 March 2021

All protocols in relation to non-invasive ventilation that were in place in December 2017
All policies in relation to non-invasive ventilation that were in place in December 2017
For the above two requests, please find attached document entitled “Non-Invasive Ventilation in Critical Care for Hypercapnic Respiratory Failure”.

All care plans in place in relation to non-invasive ventilation that were in place in December 2017
This request is refused under section 38 of FOISA as this relates to third party personal information.

Exclusion criteria for NIV

Absolute contraindications:

- Respiratory arrest / need for immediate intubation
- Facial trauma / burns / surgery / abnormalities
- Fixed upper airway obstruction
- Severe vomiting
- Acute severe asthma
- Pneumothorax (unless chest drain inserted)
- Confirmed wish by the patient not to receive NIV in the event of a deterioration.

Relative contraindications:

- Inability to protect airway
- Life-threatening hypoxaemia
- Haemodynamic instability
- Impaired consciousness
- Confusion / agitation
- Bowel obstruction
- Recent facial / upper airway or upper GI tract surgery
- Copious respiratory secretions
- Severe comorbidity

(NIV may be used despite 'relative contraindications' if this is the 'ceiling' of treatment and the patient is not for ICU / intubation.)

Patient for ICU/intubation

Discussion should involve patient if possible. There may be information from previous notes / eKIS**.**

Commencing Spontaneous/Timed (commonly known as BiPAP)

- In general while a patient might be started on NIV with an IPAP of 15cmH2O and EPAP 4cmH2O, this should be progressively increased to reach a IPAP of 20-30 cmH2O within 10–30 minutes of starting NIV, until clinical improvement achieved or patients tolerance has been reached. The higher pressure and more rapid escalation being indicated by patient size and more severe acidosis respectively
- Aim for continuous use for the first 24 hours, with breaks only for food, drink, skin and mouth-care
- Bronchodilators can be administered without interruption of NIV, via a t-piece in the circuit
- See Appendix II Philips Respironics V60 Setting and Alarms
- See Appendix III parameters explained

Monitoring NIV

- A member of the medical team must review the patient, including repeat arterial blood gases (ABGs), within 1 hour of initiating NIV.
- ABGs should be repeated at:
    - 1 hour after any change of settings.
    - 4-6 hours following commencement of treatment, or earlier in patients who are not clinically improving.
- Further invasive monitoring should only occur if clinically indicated.
- Pressure settings should be altered in accordance with blood gas results
- Continuous oxygen saturation and ECG monitoring should occur for at least the first 12 hours.
- Additional monitoring must be completed hourly. Observations should include:
    - Respiratory Rate,
    - Heart Rate,
    - Conscious level,
    - Comfort, chest wall movement,
    - Ventilator Synchrony,
    - Mask Fit/Leak.

See troubleshooting guide Appendix V

Red flags

- H+ >55 despite optimal NIV, RR persisting >25, new onset of confusion or patient distress
- Action
    - check synchronisation, mask fit, exhalation port, give physiotherapy/bronchodilators.
    - Consider mechanical ventilation

Titrating Spontaneous Timed parameters

- Current evidence suggest IPAP of 20-30cmH2O and EPAP range: 4–8 cmH2O, EPAP can be increased above 8cmH2O following expert review. . For most patients an EPAP of 4-5cmH2O will be sufficient.
- In general to improve CO2 clearance and increase tidal volumes, increase IPAP.
- In general to improve oxygenation, increase EPAP, as this will improve FRC
- Please note that increasing the EPAP without increasing the IPAP will reduce the IPAP EPAP difference. This will increase the patient's work of breathing.

Key practice point
It is important to ensure optimum medical therapy, NIV is supportive pending management of acute issue and sometimes medical therapy is overlooked e.g. nebs given on NIV.

Problems with inadequate oxygenation PaO2 (normal is between 10 - 13.5 kPa). However aiming for PaO2 > 8 kPa may be more acceptable in certain patient groups.

- A lot of patients on NIV do not have an arterial line, so aim for target saturations
- Check air leaks around the mask. Is the mask the correct size? Is there adequate seal?
- Check that there are no disconnections from the V60
- Does the Oxygen percentage need increased or does the EPAP need increased? Or do they both need increased
- Please note that increasing the EPAP without increasing the IPAP will reduce the IPAP-EPAP difference. This will increase the patients work of breathing.
- Reducing the IPAP-EPAP difference is likely to increase the CO_2 level. Therefore, any increase in EPAP should prompt a similar increase in IPAP in order to maintain the same level of pressure support.
- Increasing the IPAP will generate more tidal volume.

Problems with inadequate carbon dioxide clearance: Normal PaCO2 range: 4.5-6 kPa.

- What is the patients tidal volume? – difficult to know / assess and whilst some machines will give an indication it is important to acknowledge that NIV is not a closed system and is designed with leak for CO2 clearance.
- What is the patients respiratory rate?
    - Spontaneous or mandatory breaths
    - Most NIV is spontaneous and back up rate set
- Treat any findings as appropriate. Does the patients respiratory rate need increased.
- Does the tidal volume need increased? The tidal volume can be increased by increasing IPAP setting
- Sometimes an elevated PaCO2 is appropriate (permissive hypercapnia / acute on chronic situation). This may due to the patient's lung physiology makes PaCO2 reduction difficult or hazardous or because the patient's habitual PaCO2 is elevated.
- Permissive hypercapnia can be tolerated well in certain patient groups. **However, the patient must always be closely monitored for signs of increasing acidosis i.e. H +>45, Bicarbonate/HCO3 < 22 mmol, base becoming increasingly negative < -2**

Mask

- Size for face mask (select the smallest mask that fits comfortably):
- Small leaks 15-30 litres are permitted but not into the eyes.
- Assess mask fit by monitoring mask leak, aim to keep any leaks to a minimum.
- Demonstrate use of quick release strap
- Mask must have anti asphyxia valve

Humidification

All patients should receive dry circuit.

Heated humidification should be considered if the patient reports mucosal dryness or if respiratory secretions are thick and tenacious

Weaning

Weaning should be considered after 24 hours of NIV if the main aim has been achieved, the control of acidosis and management of underlying acute element.

Weaning should begin during the day and NIV should not be stopped abruptly

Treatment failure- escalation/palliation

Once treatment has been optimised, *failure to reverse acidosis and reduce PaCO2 levels after the first 4-6 hrs is a poor prognostic sign,* and the continuation of NIV should be reviewed by the medical team.

A decision can then be made regarding either escalation to invasive ventilation or withdrawal of NIV and palliation of symptoms, as discussed and documented at initiation of NIV.

NIV may be continued for palliation of symptoms.

Nursing care

Pressure sores

Pressure sores across the nose bridge are a significant risk (but should be uncommon with modern masks and appropriate fitting), A degree of mask leak of 15-30 litres is acceptable and the mask should be fitted to obtain the best balance between leaks and mask comfort.

Should signs of pressure damage occur, check mask fit or consider loosening head straps and accepting a larger degree of air leak. A silicone dressing can be used over the nose bridge as extra protection.

Pressure points from the mask should be assed hourly

Air Leakage

Air leakage into the eyes can cause dryness and irritation and must be addressed by altering fit or style of mask.

Fluid Intake

Patients on NIV easily become dehydrated and should therefore have their fluid balance monitored. The majority of patients should be able to tolerate short breaks from NIV for drinks and light meals. Patients using NIV may experience problems with clearance of secretions. Where this is a problem, consider nebulising normal saline through the circuit, using a T-piece.

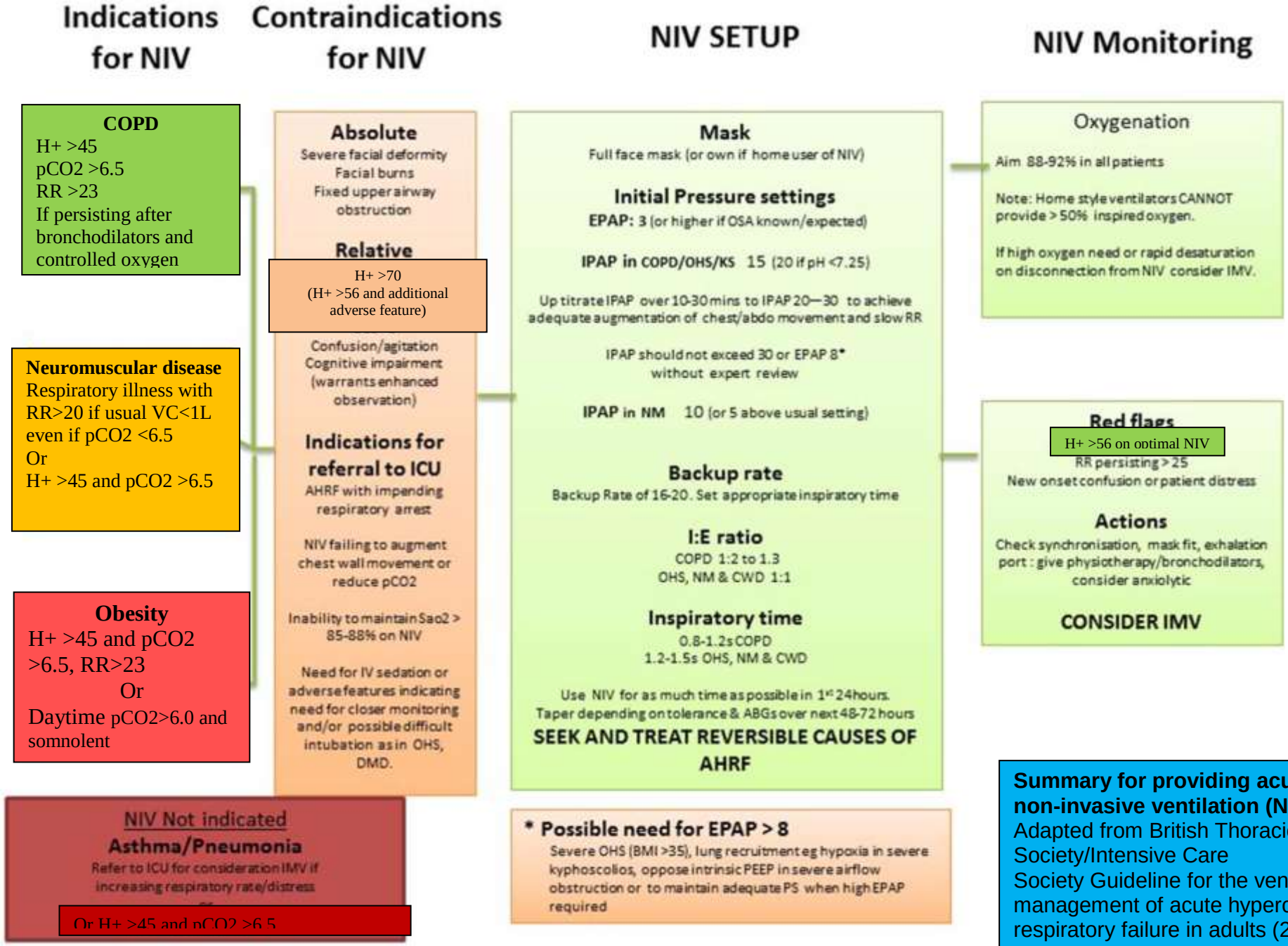
- Use T-piece nebuliser placed between the mask and inspiratory tubing. The nebuliser needs to be held upright to nebulise adequately.

Positioning

Patients should be nursed in a position which best assists breathing, e.g. high side lying, forward lean sitting or upright

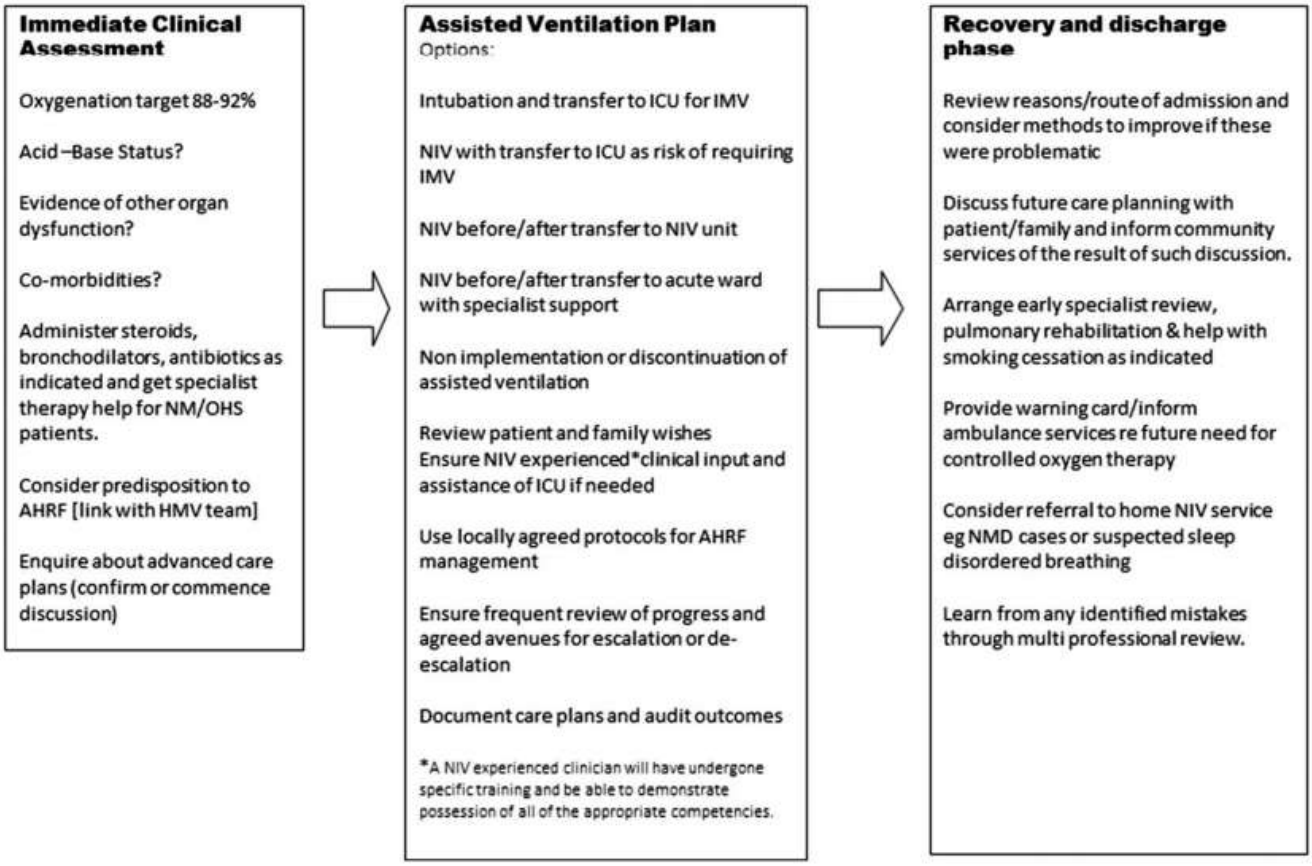
Infection control

NIV tubing, masks, exhalation ports and headgear are for single patient use only.
The inlet filter must be checked prior to the machine being used and must be replaced if discoloured.



Summary for providing acute non-invasive ventilation (NIV).
Adapted from British Thoracic Society/Intensive Care Society Guideline for the ventilator management of acute hypercapnic respiratory failure in adults (2016).
pH changed to H+ .

Appendix II The three phases of patient management in AHRF



Appendix III Phillips Respironics V60 Setting and Alarms

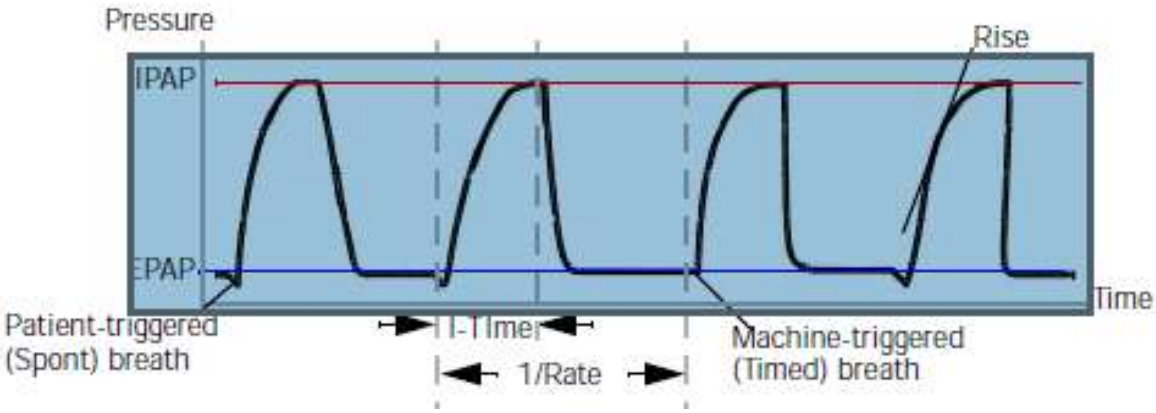
Those items in blue are most likely to be modified for each patient.

Select: (mask leak) Mask #1 or Mask #2 or Trachy & Disposable Exhalation Port (DEP) Change in menu if required.	
Choose Mode: **For S/T** **IPAP**	**S/T (BiPAP)** **Select appropriate (start) pressure:** **Suggest starting pressure: 15cm/H20** **See BTS for differences for NMD and re inspiratory time etc**
EPAP	**Suggest starting pressure: 4cm/H20**
Breath rate	**10 BPM**
Inspiratory time	**1.6 Seconds (this will give a 1:2 ration breath only used on machine delivered breath) (Appendix IV)**
Oxygen	**Select appropriate % of oxygen to maintain Sp02 (Pao2) as per medical advice.**
Rise Time **Time it takes for the flow to change ("rise up") from EPAP to IPAP** **Check PIP (Peak Inspiratory Pressure) = Set IPAP. If above "slow rise time: If below set IPAP speed up rise time**	**1 (fast) to 5 (slower)** **1= 0.1 seconds 5=0.5 seconds** **Generally select appropriate to patients respiratory rate. Suggestion** **RR>40 1 or 2** **RR 20-39 2, 3 or 4** **R<20 4 or 5**
Ramp **Set target IPAP & EPAP. Flows (pressures) increase and ramp up to target pressures gradually over set time**	**Off** **(choose time: 5-45 minutes)** 
Alarms **High and low respiratory rate**	**Set 10 breaths above and 10 breath rates below actual respiratory rate.** **NB: Low respiratory must be set higher than back up breath rate (otherwise it will be disabled) normally 2 above.**
High & low tidal volumes	**Set 100-150mls above and below measured tidal volume values**
High and low inspiratory pressure (HIP & LIP)	**Set 2-3cmsH_20 above and below set IPAP** **NB: LIP should be above EPAP**
Lip T **(Low inspiratory pressure delay time)**	**Set 15-20 seconds** **This allows the patient to get below the set LIP and return to the set IPAP without setting the LIP alarm off**
Low Minute Ventilation (MV)	**Set 1-2 litres below the measured MV**

Any concerns, speak to a senior member of nursing/ medical staff

Appendix IV Parameters for spontaneous timed (S/T) via v60

- Parameters for spontaneous timed (S/T) via v60**Helps gas go in and out.**
- **Is used to augment CO_2 removal as well as improving oxygenation**



IPAP	• **IPAP = top pressure.** As the patient breaths in, the ventilator detects a drop in pressure during the inspiratory breath and then delivers a flow of air into the patients airway until the predetermined inspired pressure (IPAP) is reached. The extra pressure enhances the breath to create a greater tidal volume. • In general to improve CO2 clearance and increase tidal volumes, increase IPAP. • Current evidence suggest IPAP of 20-30cmH2O . • In general while a patient might be started on S/T with an IPAP of 15cmH2O and EPAP 4cmH2O, this should be progressively increased to reach a IPAP of 20-30cmH2O within 10–30 minutes of starting NIV, the higher pressure and more rapid escalation being indicated by patient size and more severe acidosis respectively. • Please note that if H+ >56, initial IPAP setting should be 15 cmH2O.
EPAP	• **EPAP= bottom pressure** • When the patient breaths out a predetermined pressure is kept in the lungs (EPAP) that maintains the alveoli in an open position facilitating gas exchange[5.] • Current evidence suggest EPAP range: 4–8cmH2O • EPAP can be increased above 8cmH2O following expert review. • In general to improve oxygenation, increase EPAP, as this will improve FRC
I-Time (Inspiratory Time)	• Time to deliver the required gas. • Inverse ratio ventilation is not allowed • Can be set 0.30 to 3.00 secs • If back up rate is changed, change I-Time accordingly (see table).

Rate (Back up respiratory rate)	• Respiratory frequency or number of breaths per minute. • Inverse ratio ventilation is not allowed. • Change I-Time accordingly see table • Back up rate for acute hypercapnic respiratory failure in adults is between 10-20. • Set low rate alarm 2 above back up rate.
Rise (Rise Time)	• Speed with which inspiratory pressure rises to the set (target) pressure. • If the Rise Time is insufficient to reach the target IPAP pressure(monitor Peak Inspiratory Pressure), adjust the Rise Time or I-Time setting. • Can be set between 1 to 5 (1 is fastest)

Appendix V Back up rate and inspiratory times

BACK UP RATE	INSPIRATORY TIME
6	3.3
8	2.5
10	2
12	1.6
14	1.4
16	1.2
18	1.1
20	1

Inspiratory time only takes effect when a backup breath is delivered.

Appendix VI Non-invasive ventilation problem solving

Problem	Cause	Preventive measure s
Dys-synchrony between patient and ventilator	Wrong tubing? Poor respiratory effort may not be sufficient to trigger breaths Check machine settings / triggers – modern machines will cope well generally. ? anxiety / dysfunctional breathing component – morphine / midazolam can sometimes prove helpful	Ensure correct tubing is used in the circuit. It must be smooth on the inside to allow flow to be detected by the machine. An increase in EPAP may help. If the patient is very tachypnoeic, ensure rise time is as quick as possible.
Mask leaks. Some leaks are expected – required for CO2 clearance due to single limb circuit – aim usually around 20 litres/min and machine alarms may guide. However excessive leaks can contribute to inefficient ventilation. Additionally this may contribute to eye and noise irritation	Wrong size/fitting of face mask. Nasogastric tube preventing tight fit of mask to the patients face - ?review need for NG	Reassess and check the size of the mask size Readjust the head strap but avoid over tightening the head strap. Use a foam dressing to customise the mask for a better fit if possible Adjust the flow to allow for the leaks Does the patient have false teeth, does the mask fit better without the false teeth
Gastric distension	Positive pressure from the Respironics V60 may cause stomach insufflations	Discuss with medical staff if flow on CPAP or IPAP (via Bilevel positive airway pressure) machine can be reduced. A NG tube may be inserted to decompress the stomach
Intolerance or lack of compliance of treatment	Confusion may be due to hypoxia or hypercapnia, sepsis.	Perform Arterial Blood Gas to evaluate gas exchange Patient may require one to one supervision until Arterial Blood Gas have improved or normalised
Persistent hypoxaemia	Oxygen tubing may not be attached or may be leaking Patient's condition is	Check all connectors and oxygen supply Increase flow and or oxygen on CPAP. On S/T increase EPAP and increase

	deteriorating Atelectasis	IPAP to maintain the same level of pressure support Seek medical review
Hypocapnia Normal PaCO2 range: 4.5 – 6 kPa.(Patients may run with higher PaC02).	Ventilation/ respiratory rate may be too set to high • Is it spontaneous • Is it mandatory The patient's condition may have improved and the NIV machine may be now over-ventilating the patient	Reduce ventilation rate Reduce IPAP if on BiPap Assess whether the patient still requires non-invasive ventilation.
Pressure damage or painful nose (should be uncommon with modern masks and appropriate fitting)	Mask may be too tight or may not be correctly positioned	Undertake frequent inspections of pressure areas to check for potential damage Use a silicone dressing.
Dry mouth	High flows of air dry oral secretions	Perform regular oral care during breaks in non-invasive ventilation Does the patient need wet humidification
Hypercapnia • **Check hydrogen ions-** main aim is control of acidosis and management of underlying acute element. Consider permissive hypercapnia: sometimes an elevated PaCO2 is appropriate, because of the patients lung physiology makes reduction difficult because the patient's habitual PaCO2 is elevated	Exhalation port blocked, or inadequate intentional leak Insufficient tidal volumes being achieved Patient has insufficient respiratory drive • Check opiate intake Wrong size of face mask.	Ensure port is open Check tidal volume and rate Increase IPAP Check tidal volume and rate Increase IPAP Reassess and check the size of the mask size